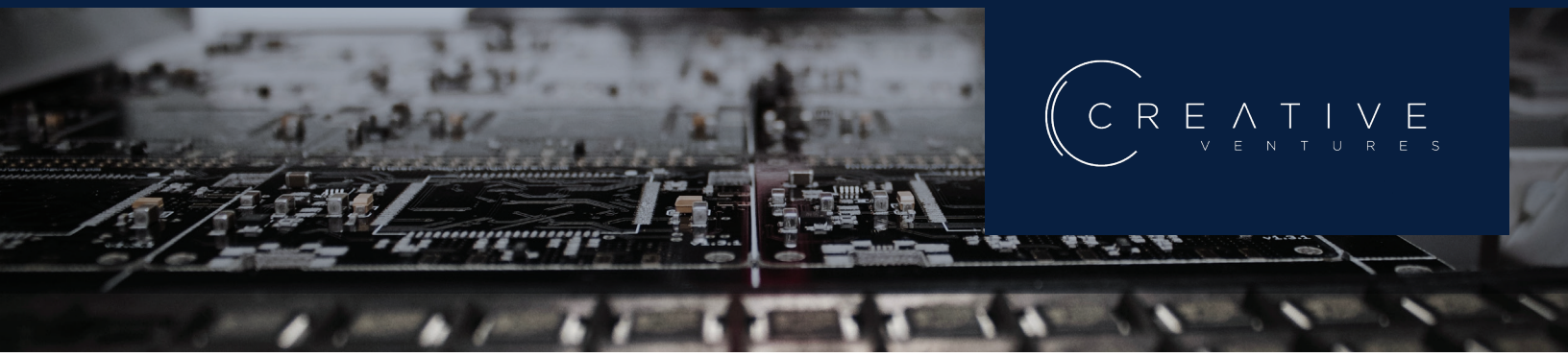

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Investment in construction automation is essential to rebuilding US infrastructure

One of the greatest problems facing the construction industry remains a lack of labor, making automation a necessity for moving forward with ambitious national infrastructure projects.

With the United States moving all-in on massive infrastructure investment, much of the discussion has focused on jobs and building new green industries for the 21st century. While the Biden administration's plan will certainly expand the workforce, it also provides a massive opportunity for the adoption of automation technologies within the construction industry.

Despite the common narrative of automating away human jobs, the two are not nearly as much in conflict, especially with new investments creating space for new roles and work. In fact, one of the greatest problems facing the construction industry remains a lack of labor, making automation a necessity for moving forward with these ambitious projects.

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The residential construction industry alone had some 223,000 and 332,000 unfilled construction job vacancies at the peak unemployment rate of 15% in 2020, but that's actually about the same when unemployment was only at 4.1%. Between 1985 and 2015, the average age of construction workers increased from 36 to 42.5, while those aged 55 and older increased from 12% to over 20%. The 2018 Population Survey conducted by the Census Bureau found that workers under 25 comprised just 9% of the construction industry, compared to 12.3% of the overall U.S. labor force.

Productivity in the construction industry has likewise remained static since 1995, primarily driven by the aging demographic of the existing labor force, the apprenticeship nature of the job, and difficulty in attracting and retaining new workers. In short, there is insufficient labor to do the job, while existing staff are becoming increasingly less productive as skilled workers that have accumulated decades of experience in their crafts are lost due to retirement.

Automation will need to be a key element of any major infrastructure push, especially if we hope to meet the ambitious goals of current proposals. That being said, not all areas of the construction industry are primed, or even viable, for this shift to automation.

The challenges of construction automation

Construction is one of the world's largest industries but has two major challenges: market fragmentation and complex stakeholders.

The construction industry as a whole is nationally fragmented but occasionally locally concentrated. This differs depending on the segment and type of construction company, with each generally comprising less than 10 workers. The top 100 general contractors account for less than 20% of the total construction market. Subcontractors are even more fragmented, with top players accounting for less than 1% of the total market share. This makes sales processes and scaling very slow and highly inefficient.

The number of different players that must work together also increases market dynamic complexity. Aligning interests among developers, general contractors and subcontractors can be extremely challenging.

Developers want contractors to reduce cost, but they cannot force developers to adopt any particular automation technologies or analytical tools beyond a typical bidding process. General contractors that want to deploy site management tracking tools to improve collaboration and productivity often incur resistance from the many subcontractors engaged for the job. Once completed, the new project might use an entirely different set of subcontractors, renewing the friction of technological advancement acceptance.

Successful technologies and investments, therefore, need to focus on segments that can best adapt to scalability and ensure alignment of interest among different stakeholders in the industry. These areas are limited but offer huge potential and impact.

Analyzing automation opportunities

Although many of today's construction technology companies are operating on the latter part of the construction process, some of the most attractive opportunities are jobs required in the early part of the process, during site preparation and foundation installation.

One of the most labor-intensive processes in site preparation is topography adjustment, which requires excavation and leveling. Autonomous construction vehicles are the obvious solution, but adoption has been slow due to a number of operational challenges. With support from increased drone technologies, the surveying market is ripe for disruption.

Companies like Civ Robotics are automating labor-intensive tasks such as construction staking, whereby a surveyor marks the location of proposed new structures. However, solving the surveyor labor shortage directly is not highly lucrative because this market is significantly smaller than the excavator market that has similar operational challenges. Rather than automating surveying fieldwork, it may be more beneficial to automate what they do "on the desk."

The surveying field has recently seen increased data collection, with the challenge shifting from simple operations to analytical manipulation of the resulting geospatial data. One technical issue is translating 3D drone data from lidar or photogrammetry into more commonly used 2D data such as CAD drawing, which is traditionally performed either by the surveyors or CAD engineers.

One company tackling this is AirWorks, which automates data translation collected by drones, giving surveyors more time to spend in the field and resolving the shortage of CAD engineers, an increasing number of which are now attempting to "graduate" into higher-paying engineering roles. The construction surveying market offers a great beachhead to build an automation tool on top of the broader geospatial market across multiple industries, following the previous success of companies such as Trimble.

The challenge presented by direct automation of construction is that most are extremely intricate and not repeatable. Electricians installing electrical wiring or carpenters building the frame of a structure perform tedious tasks that vary across the field and require large amounts of contextual information that state-of-the-art AI and robotics technologies are unable to replicate.

However, for almost all construction sites, the foundation process is primarily concrete-based. The foundation footing comprises 15%-30% of the entire construction cost. Processes such as rebar and concrete pouring are challenging but relatively repeatable, with companies such as Toggle and Rebartek attempting to tackle this problem. Sufficiently versatile technologies that improve repeatability with minimum setup time are still limited but hold great potential.

The need for better management

Time and cost overrun are the norm in the construction industry. According to KPMG, only 25% of construction projects were completed within 10% of their original deadlines, while only 31% of all projects came within 10% of the budget. Furthermore, large projects typically take 20% longer to finish than scheduled and are up to 80% over budget, while 98% of megaprojects incur delays or exceed their budget. The problem is exacerbated in largescale infrastructure, in which overrun of capital expenditure can be as much as 80%, with delay beyond

the original schedule as much as 20 months against a typical three- to six-year project timeline.

We cannot necessarily fill in a gap of some specific construction jobs due to technological and market structure hurdles; therefore, the only viable solution is to enhance overall construction management productivity to improve delays and cost overruns.

Decisions made early in the conceptual planning and design phases have a dominant influence on project cost and completion time. Consequently, solutions that enhance the construction management process during the pre-construction phase have a greater impact on the project, thereby creating value for the asset owners and general contractors who are likely to be the customers of these solutions.

Over the past couple of years, a field called generative design, which attempts to standardize design inputs and create consistent outputs, has emerged. Using a linear optimization approach, generative design creates a number of outputs, often limited but in great specificity, that meet certain criteria such as the number of toilets or the amount of required sunlight.

Generative design may reduce design errors but it is a highly inflexible tool that requires pre-specifying the inputs and deterministic variables in advance. This often does not match the existing design and construction processes that are more fluid and creative. Customer requirements may also change and evolve throughout the construction process.

We have yet to see a tool that offers the best of both worlds, comprising a high degree of design specificity that eliminates ambiguity without needing a complete library of deterministic inputs. Such a tool is likely to look less like autocorrect and more like Google's Smart Compose, which predicts text in a Google Doc. An AI tool that demonstrates the ability to predictively resolve design errors, whether by automating key features or searching for potential glitches, will greatly reduce cost and time overrun along the entire chain.

Likewise, in the complex construction planning phase, many construction companies are adopting the more detailed 3D design of building information modeling (BIM). Companies like ALICE offer an AI-powered construction simulation and optimization platform that deconstructs and breaks down BIM design for a given project into a task-by-task schedule.

The software allows companies to optimize different cost parameters such as labor, vehicles and tooling against project schedule to determine the most cost-effective and least labor-intensive solution to meet both budget and schedule.

One day, a cost planning tool will appear that utilizes augmented reality/virtual reality (AR/VR) and lets users manipulate the design while recalculating the cost in real time and integrating with scheduling tools to triangulate between design, cost and schedule.

The next decade's infrastructure boom

Automation will be essential to any substantial infrastructure effort, not only for the cost savings but to close the gap on labor as well. Most companies in this space are still trying to optimize on the far end of the spectrum, where each improvement is incremental at best. The much harder and more ambiguous problem at the earlier phase of the construction process offers a much greater impact.

Good management early in the project is far more likely to help companies save valuable resources in the long run. The challenge of ambiguity can be dealt with using the power of big data and predictive analytics. Solving the construction design and scheduling upfront and supplementing them with analytics concerning construction monitoring is likely to help the company curb rising costs and time constraints as industry norms.

The estimated value of the U.S. construction industry is $1.3 trillion, of which about $400 billion is made up of construction labor. With infrastructure investment now a major priority, automation in this space will be one of the biggest opportunities over the next decade.